A Synopsis

of the proposed thesis entitled

A STUDY OF MIXED CONVECTION FLOWS OF FLUIDS IN A VERTICAL CHANNEL

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Introduction

There are three modes of heat transforms namely conduction, convection, and radiation. The study and analysis of the flow properties of non-Newtonian fluids is very much important in the field of fluid dynamics due to their technological applications. Mechanics of non-Newtonian fluids presenting challenges to engineers, mathematicians, physicist and research scholars in this field. Not many researchers have shown interest in the study and research of flow of fluids in a various flow fields due to complex stress strain relationship of non-Newtonian fluids. A convection condition where the effects of forced as well as free convection is normally treated as mixed or combined convection. In a mixed convection flow of both free and forced convections have comparable magnitude. So in this situation both forced and free convection happen simultaneously which means mixed convection occurs, where the effect of forced flow on buoyant flow is notable. The baffles are arranged for cooling the temperature in passage for thermally developed flow. The subject of channel flow has been investigated extensively and a few studies yet to be evaluated for these effects.

The combination of heat and mass transfer in porous media is gaining attraction due to wide interesting applications in engineering. In this case the flow phenomenon is relatively complex as compared to pure thermal or solute transport. Some examples like the transport of contaminants in saturated soil, migration of moisture in fibrous insulation etc. The most common technique for internal cooling enhancement is placement of periodic ribs. Ribs are generally mounted on heat transfer surface which disturb the boundary layer growth and enhancement of heat transfer between surface and fluid. A plane baffle may be used as an insert to increase the rate of heat transfer in the channel. Also a thin perfectly conductive baffle used to avoid a appreciable increase in transverse thermal resistance into the channel. The concept of Regular Perturbation method is used to solve non-linear differential equations. The results so obtained are studied graphically for different parameters. In last few years the mixed convection flow in porous medium has become an interesting and wide topic of research study for many researchers due to its scope for several applications in many areas of science and engineering.

Review of Literature

The dual solutions occurring in the problem of mixed convection flow over the vertical surface through a porous media with constant temperature in case of opposing flow has been notified by J.H. Merkin. Aly, Nazar and Pop et.al have found the existence of dual solutions to the mixed convection in a porous medium. Recently Prathap Kumar, Umavathi et.al observed the free convection in vertical double passage wavy channel for both Newtonian and non-Newtonian fluid. The combined heat and mass transfer by free convection with boundary layer approximates has been studied by Bejan, Khair. Lai, Kulacki, Murthy and Singh coupled heat and mass transfer by mixed convection in Darcian fluid saturated porous media which has been analyzed by Lai. Recently Prathap Kumar et.al studied homogenous and heterogeneous chemical reaction of immiscible fluids.

Recently Prathap Kumar and Umavathi studied the mixed convection of non-Newtonian fluid in vertical double passage channel. The importance of mixed convection was firstly discussed by Cheng on liquid dominated geothermal reservoirs. Seid and Pop found the numerical study of mixed convection from the two thermal sources in a vertical porous layer. Umavathi et al. presented a numerical study of mixed convection in a vertical channel filled with a porous medium. Barletta et.al. supposed the Darcy mixed convection with viscous dissipiation in a vertical and inclined channel respectively. The dispersion of a solute in a viscous liquid flowing in circular pipe under laminar conditions was observed by Taylor and Aris. Ramanna Rao and Padma studied effects of chemical reaction on dispersion in Newtonian fluids. The theory of micropolar fluid was first developed by Eringen. A more recent study of micopolar fluid study was given by Luckaszewicz. The free micropolar convection in case of asymmetric boundary conditions was given by Chamkha et.al.. Umavathi, Jeweria and Prathap Kumar have studied flow and heat transfer of micropolar fluid in a vertical channel. Mixed convection heat transfer of non-Newtonian fluids on flat plate has been studied with the help of modified power law viscosity model by Molla and Yao.

Objectives of the Research

In the present study the researcher will study and analyse the velocity, temperature and concentration fields for a viscous fluid in a vertical channel in presence of the first order chemical reaction containing a thin conducting baffle. The researcher will observe the effects of thermal Grashoff number GRt on velocity and temperature graphically at different baffle positions. The effect of mass Grashoff number GRc on flow can be studied graphically at different baffle positions. He will observe effect of GRc on velocity and temperature in both streams at baffle position and also see the effect of Brinkman number Br on flow field graphically. He will examine effect of increasing mass Grashoff number which implies increase in concentration buoyancy force and so increases the fluid flow.

The growing need for chemical reactions in chemical and hydro, metallurgical industries need the study of heat and mass transfer in presence of chemical reaction. This study aims mathematical model for steady mixed convection heat and mass transfer saturated with porous medium in vertical channel by inserting a perfectly thin conducting baffle. The problem of mixed convection heat and mass transfer in a vertical double passage channel filled with different fluids will be investigated. The researcher will study the effects of different medium parameter and at the same time effects on temperature in different streams at baffle positions. The researcher will observe the effects of thermal grashoff number on velocity and temperature in both streams at baffle positions. The features of flow and heat transfer properties will be analyzed by plotting graphs and discussion in details. We will examine the effect of first order chemical reaction in a vertical double passage channel in a various medium. The problem of fully developed convection of heat and mass transfer in a vertical double passage channel with different temperature will be studied.

Methodology to be used for the Present Research

• Collection of references through research journals and internet.

• Understanding the knowledge about the current research by attending various conferences, workshops, symposiums and seminars.

• Regular perturbation method is used for solving the nonlinear system of governing equations which are valid for small values of Brinkman number.

• For relaxing the constraints the nonlinear equations are solved by Regular Perturbation method.

The basic differential equations governing the flow and heat transfer may be solved using the following techniques (methods):

1. Linearization Techniques

2. Power Series Method

3. Regular Perturbation Method

4. Finite Difference Method

5. Shooting Method

Importance of the Study:

Convective heat transfer in a vertical channel is having a huge practical importance in many engineering systems such as the design of heat exchangers, solar energy collection and the cooling of an electronic system. The idea of mixed convection is to enhance heat flow is important objective in numerous engineering application of nano fluids and micro fluids such as pumping systems; chemical catalytic reactors, plate-fin heat exchangers, electronic cooling system etc.

The combination of heat and mass transfer in porous media is gaining attraction due to wide interesting applications in Engineering. In this case the flow phenomenon is relatively complex as compared to pure thermal or solute transport. Some examples like the transport of constraints in saturated soil, migration of moisture in fibrous insulation. This type of investigation is useful in knowing heat and mass transfer characteristic for solidification and centrifugal casting of metals, biomechanics and geophysical problems and petroleum industry.

The problem of fluid flow and convection heat transfer inside porous media is mostly experienced in many fields of science and engineering such as civil engineering, mechanical engineering, petroleum and chemical engineering, hydrology, thermal management of electronic cooling. The development of performance of heat transfer in porous media has been studied both experimentally and theoretically by many authors. Dispersion of solute describes spread of particles through random motion from regions of higher concentration to regions of lower concentration .The dispersion of solute play an important role in physiological system such as the knowledge of materials injected in a blood vessel is useful for many physiological and clinical purposes also spreading of drugs in human body. This type of observance is useful in knowing heat and mass transfer characteristic for solidification and centrifugal casting metals, biomechanics and geophysical problems and petroleum industry.

The subject of convective flow with heat and mass transfer has been extensively studied because of its importance in chemical and nuclear industries but in recent years the study of heat transfer in vertical channel flows through a porous media has become a study of interest by many researchers in a view of application in engineering problem such as storage of radioactive nuclear waste. The study of micropolar fluid got much attention in cast several years due to traditional Newtonian fluid can’t precisely describe the properties of fluid flow for a fluid having suspended particles.

Proposed Work Plan / Formulation and Structure of Study

Year wise planning and target to be achieved.

First Year Plan:

During this period the researcher will collect basic research material needed for research such as books, journals, research papers etc. related to the topic of the study. Also researcher will complete course work in first step of research. The researcher will build the background needed for his research. The researcher will participate in national, international conferences, workshops, seminars, specialized trainings and he will submit his research progress report to the university.

Second Year Plan:

The researcher will meet the prominent mathematicians to discuss and verify his findings. He will confirm whether his study and findings meet the objectives or not. He will also prepare the research papers based on his research topic to publish in UGC recognized journals. The researcher will present his findings in national and international conferences. He will submit the progress report to the university.

Third Year Plan:

The researcher will verify the objectives of his research. The outcomes of the research will be published in UGC recognized journals and presented in workshops, seminars, national and international conferences throughout this year. At this stage the researcher will hold discussions with other researchers, professors, research supervisors and students. He will try to be ready for his Pre Ph.D. viva-voce and submit the final synopsis and thesis to the university in the prescribed and recommended format.

REFERENCES

1. **Prathap Kumar J., Umavathi J.C. and Jagtap Sharadkumar** "Effect of First Order Chemical Reaction in a Vertical Double Passage Channel" **International Journal of Engineering Research and Application** ISSN:2243-9642 Vol.3 Issue 3, Issue 5, PP -967-977, 2013.

2. Prathap Kumar J., Umavathi J. C. and Jagtap Sharadkumar "Heat and Mass Transfer for a Chemically Reaching Permeable Fluid in a Vertical Double Passage Channel" **International Journal of Engineering Research and Technology (IJERT)** ISSN 2278-0181, Vol.2 Issue 10 Oct., 2013.

3. **Prathap Kumar J., Umavathi J. C. and Jagtap Sharadkumar** "Effect of First Order Chemical Reaction in a Vertical Double Passage Channel Filled with Porous Matrix", **International Journal of Mathematical Archieve**, Vol.5(12) pp 94 -116 , 2014.

4. **Prathap Kumar J., Umavathi J.C. and Jagtap Sharadkumar, "**Natural Convection Heat and Mass Transfer of a Chemically Reacting Micropolar Fluid in a Vertical Double Passage Channel" **International Journal of Science and Research** ISSN (online) 2319-7094 Volume 4, pp.653-659, 2015.

5 .**Prathap Kumar J ,Umavathi J. C. and Jagtap Sharadkumar** "Effect of First Order Chemical reaction in a Vertical Double Passage Channel Filled with Micropolar Fluid'' **International Journal of Innovative Research in Advanced Engineering (IJIRAE)** ISSN :2349-2163 Issue 4 Volume 2 pp 132-143 April, 2015.

6. **Pratha**p **Kumara J. and Karuna Prasad, J. C. Umavathi "**Fully Developed Mixed Convection in a Vertical Double passage Channel Saturated with Porous Medium using Robin Boundary Conditions" **Intenational Journal of Computer and Mathematical Sciences(IJCMS)** ISSN 2347-8527,Vol.5,Issue5,pp 51-77, May, 2016.

7. **Pratha**p **Kumar J., J. C. Umavathi J**. **and Karuna Prasad "** Effect of Viscous Dissipation on Mixed Convection Flow in a Vertical Double Passage Channel Using Robin Boundary Conditions" **International Journal of Engineering, Sciences and Technology,** Vol.8, 2016.

8. **Pratha**p **Kumar J., J. C.Umavathi B. J. Gireesha and M. Karuna Prasad** " Mixed Convective Flow in a Vertical Double Passage Channel Filled With Nanofluid Using Robin Boundary Conditions" American Scientific Publishers,Vol.5,pp 1-11, 2016.

9. **Umavathi J.C., I.C. Liu and Ali J. Chamkha** " Mixed Convection Flow in a Vertical Channel Filled with a Fluid Saturated Porous Medium Divided by a Perfectly Conductive Baffle" **International Journal of Microsale and Nanosale** Vol.5,pp. 127-147, 2016.

10. **Umavathi J.C.** "Mixed Convection of Micropolar Fluid in a Vertical Double Passage Channel" International Journal of Engineering Science and Technology" V**ol.** 3, no.8 pp197-209, 2011.

11. **M. Karuna Prasad, J**. **Pratha**p **Kumar and J. C.Umavathi "**Effect of Baffle on Mixed Convection Flow in a Vertical Channel Filled With Electrically Conducting Fluid" International Journal of Engineering Research and ApplicationVol.9,pp -12-40, 2019.

12. **Cheng, P., "**Combined Free and Forced Convection Flow about Inclined Surfaces in Porous Media, Int. J. Heat Mass Transfer, 20(8)(1977),807-814.

13. **Prathap Kumar J., Umavathi J.C. and Basavraj M. Biradar, "**Mixed Convection of Composite Porous Medium in a Vertical Channel with Asymmetric Wall Heating Condition", J. Porous media, Vol. 30(3), pp 271- 285, 2010.

14. **Cheng C.Y.,** Fully Developed Natural Convection Heat and Mass Transfer of Micropolar Fluid in a Vertical Channel with Asymmetric Wall Temperatures and Concentrations, Int. Comm.Heat Mass Transfer, Vol.33,pp 627-635, 2006.

15**. F. Chorlton** "Textbook of Fluid Dynamics" CBS Publishers and Distributors, New Delhi, First Indian Edition 1985.

16. **J. L. Bansal** "Viscous Fluid Dynamics" Oxford and IBH Publishing Co., 1977.

17. **H. OCKENDON and J. R. OCKENDON** "Viscous Flow" Cambridge University Press, 1995.

18**. David Pneueli and Chalm Gutfinger "**Fluid Mechanics" Cambridge University Press,1992.

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